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(54) Process for the production of a water-soluble polymer dispersion.

(57) A process for obtaining a dispersion of a water-soluble polymer comprises dissolving a monomer in an aqueous solution of at least one salt and conducting polymerization while depositing the polymer as fine particles in the presence of a dispersant.

"Process for the Production of a Water-soluble Polymer Dispersion"

THIS INVENTION relates to a process for the production of a dispersion of a water-soluble polymer, which polymers are widely used, for example as flocculating agents for waste water treatment, dehydrating agents, chemicals
5 for use in paper making processes, dispersion stabilizers for various suspensions, soil improvers and so on.

Heretofore, as processes for the production of water-soluble polymers used in such fields as those described above, there have been proposed, for example,
10 stationary polymerization in an aqueous solution, water-in-oil type emulsion polymerization (Japanese Patent Application Laid-open No. 102388/1979), and suspension polymerization in a hydrophobic solvent (Japanese Patent Application Laid-open No. 69196/1979).
15 Furthermore, Japanese Patent Application Laid-open No. 70489/1975 discloses precipitation polymerization in an aqueous solution of a salt and Japanese Patent Publication No. 14907/1971 discloses polymerization in an aqueous solution mainly comprising acrylic acid
20 at a low pH and containing a salt.

In stationary polymerization in an aqueous solution, because the polymerization is conducted at a monomer concentration of 10% by weight or more in order to obtain a polymer of a high molecular weight, the product is
25 in hydrated gel form and hence cannot be easily dissolved as such and therefore it is necessary either to dilute and sell the same as a flowable, low concentration product or to dry it to a powder. Where it is put on the market at a low concentration, the transport cost is increased,
30 whereas the heat energy required for drying to a powder

is great. Also, three-dimensional crosslinking is brought about by heating and an undesirable water-insoluble part is produced.

5 The water-in-oil type emulsion is inflammable and also has the disadvantage that valuable organic solvents are wastefully consumed. With the suspension polymerization in a hydrophobic solvent, because inflammable substances such as cyclohexane and toluene are used, there is the disadvantage that an enormous
10 cost is required for the production apparatus.

Although precipitation polymerization in an aqueous salt solution is low in equipment cost and is a good process, it has the drawback that the polymer formed tends to stick together and grow into a mass, rendering
15 handling very difficult.

In the process described in Japanese Patent Publication No. 14907/1971, the dispersion is stable only under acidic conditions, and when the carboxyl groups are dissociated, it turns to a gel. However,
20 since an anionic flocculating agent generally manifests its effect by dissociating the carboxyl groups and extending the polymer chain, the acidic flocculating agent does not manifest a satisfactory effect if not neutralized before use except in the case where it is
25 used in an alkaline solution at a high pH. Furthermore, it is difficult using this process to produce a polymer flocculating agent having a degree of anionization of 15 mole % or less which is most effective as a flocculating agent.

30 It is an object of the present invention to enable the provision of a process for the preparation of a water-soluble polymer dispersion whereby the above disadvantages may be overcome or at least mitigated.

This invention accordingly provides a method of
35 obtaining a dispersion of a water-soluble polymer by dissolving a monomer in an aqueous salt solution and conducting polymerization while depositing the polymer

as fine particles in the presence of a dispersant. The aqueous salt solution is required to dissolve the monomer and precipitate the polymer.

As the dispersant, a polymer electrolyte and/or a polyol soluble in an aqueous salt solution is/are effective.

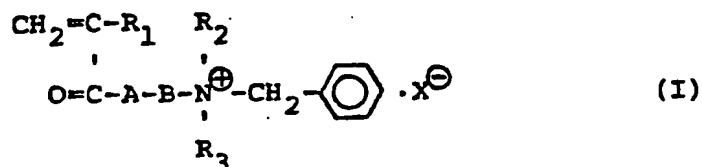
Where the deposited polymer is an anionic or cationic polymer electrolyte, the polymer electrolyte used as the dispersant is required to have charges of the same kind as the deposited polymer.

The amount of the dispersant used should be 0.1% by weight or more based on the aqueous salt solution. The polymer dispersion obtained is of low viscosity and has good flowability, and thus is convenient for transport by pumping or dissolution. Since no organic solvent is used, there is no risk of inflammability and also the cost is low.

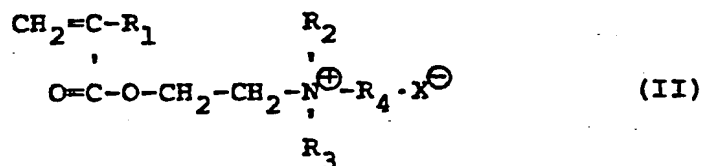
The invention relates in a preferred aspect to a process for the production of an easily flowable water-soluble polymer dispersion which comprises polymerizing an acrylic water-soluble monomer (A) while depositing the polymer with stirring in an aqueous salt solution, in the presence of a dispersant (B).

Examples of the acrylic water-soluble monomer (A) include (meth)acrylamide, N,N-dimethylacrylamide, (meth)acrylic acid

alkali metal salts, 2-acrylamido-2-methylpropanesulfonic acid
alkali metal salts, cationic monomers represented by the
following formulae (I) and (II):



wherein R_1 is H or CH_3 ; R_2 and R_3 are each an alkyl group of 1 - 3 carbon atoms; A is an oxygen atom or NH; B is an alkylene group of 2 - 4 carbon atoms or a hydroxypropylene group; and X^- is an anionic counterion,



wherein R_1 is H or CH_3 ; R_2 and R_3 are each an alkyl group of 1 - 3 carbon atoms; R_4 is H or an alkyl group or alkanol group of 1 - 3 carbon atoms; and X^- is an anionic counterion, and the like.

While one or a combination of two or more of the above-described monomers may be selected, since the polymerization is conducted while depositing the polymer ~~as described in Claim 1~~, there is one requisite that the formed polymer of

the monomer (A) be not soluble in the salt aqueous solution. Although as regards the nonionic monomers such as acrylamide etc., this invention can be carried out even in the case of homopolymerization, the ionic monomers other than the monomers of the formula (I) cannot be homopolymerized since the polymers are soluble in the salt aqueous solution.

For that reason, for the ionic monomers other than those of the formula (I), copolymerization with anionic monomers such as acrylamide etc. is preferred and the amount is suitably 15 mole % or less.

As regards the cationic monomers of the formula (I), a highly hydrophobic benzyl group is attached to the amino group, and, as a result, the monomers of the formula (I) do not dissolve in the salt aqueous solution even in the homopolymerization and may be used at proportions in ^athe wide range.

Further, since this invention relates to a process for the production of a water-soluble polymer, as long as the polymer of the water-soluble monomer (A) is water soluble, the combination of the monomers is not restricted to those described above. For example, a monomer having solubility in water to some degree such as acrylonitrile etc. may also be used as long as the copolymer with the water-soluble monomer (A) is water-soluble.

There is a requirement that the salt aqueous solution which is a dispersion medium for the polymerization ^{should} not dissolve the polymerization product. Representative salts include sodium sulfate, ammonium sulfate, magnesium sulfate, aluminum sulfate, sodium chloride, sodium dihydrogenphosphate, diammonium hydrogenphosphate, dipotassium hydrogenphosphate and mixtures of two or more of these salts. Apart from these salts, those ^{others} which do not dissolve the polymerization product are also encompassed in the scope of this invention.

While the concentration of the salt aqueous solution is not particularly restricted and varies depending on the molar ratio of the ionic monomers and the salt used, the range of from 15% by weight to the upper limit of solubility is generally preferred. Further, it is also possible to reduce the viscosity of the dispersion by further adding the salt in the range of solubility to the dispersion after polymerization.

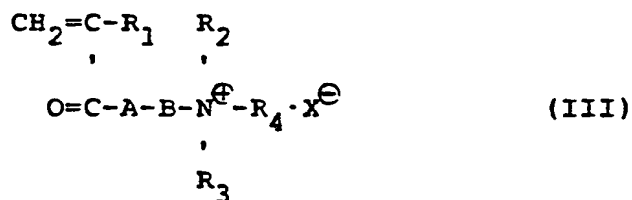
The amount of the dispersant used is preferably 0.1% by weight or more based on the salt aqueous solution, and with less than 0.1%, the formed polymer cannot be obtained in a dispersed form and sticks to each other to grow into a bigger mass, and thus it is not preferred. Examples of the polyol to be co-present as the dispersant on polymerization

include ethylene glycol, propylene glycol, glycerin, pentaerythritol, sorbitol, and polyethylene glycol, polypropylene glycol etc. of a molecular weight of up to 600, but are not restricted thereto.

Further, the polymer electrolyte to be co-present as the dispersant on polymerization is not particularly restricted as long as it is soluble in the salt aqueous solution used for polymerization.

Where the formed polymer is nonionic like polyacrylamide, either cationic polymer electrolyte or anionic polymer electrolyte may be used, but where the formed polymer is anionic, then an anionic polymer electrolyte is preferred and where cationic, then a cationic polymer electrolyte is preferred.

The anionic polymer electrolyte is preferably a polymer of an acrylic acid alkali metal salt, a 2-acrylamido-2-methylpropanesulfonic acid alkali metal salt, or a copolymer containing at least 30 mole % thereof, and the cationic polymer electrolyte is preferably a polymer of one or more cationic monomers of the following formula (III) or a copolymer containing 20 mole % or more thereof:



wherein R_1 is H or CH_3 ; R_2 and R_3 are each an alkyl group of 1 - 2 carbon atoms; R_4 is H or an alkyl group of 1 - 2 carbon atoms; A is an oxygen atom or NH; B is an alkylene group of 2 - 4 carbon atoms or a hydroxypropylene group; and X^- is an anionic counterion.

While representative examples of the cationic monomers of the formula (III) include dimethylaminoethyl (meth)acrylate, dimethylaminopropyl (meth)acrylate, dimethylaminohydropropyl (meth)acrylate and those obtained by quaternizing those with methyl chloride, dimethylsulfuric acid etc., monomers satisfying the formula (III) may all be used.

The polymerizing method is outlined below, and more detail will be later described in the examples.

A predetermined acrylic water-soluble monomer (A) is charged into a ~~an~~ salt aqueous solution in which a dispersant has been already dissolved, oxygen ~~was~~^{is} displaced by nitrogen gas, then a polymerization initiator is added, and the polymerization is started with stirring. When the polymerization reaches completion, polymer particles of a particle diameter of 1 mm or less may be obtained in a dispersed form. The monomer concentration at that time is ~~any~~ in the range of 5 parts by weight or more based on 100 parts by weight of the salt aqueous solution, and if it is less than 5 parts by weight, there is no superiority to

aqueous solution polymerization. On the other hand, the upper limit is where the flowability of the product is lost.

The polymerization temperature varies depending on the kind of the polymerization initiator and is not particularly restricted as long as the initiator functions well. Further, the polymerization initiator is not particularly restricted, and, for example, the conventionally employed redox type, azo type etc. may be used.

(Examples)

This invention is more particularly described by the following examples, but it should be understood that this invention is not limited to these examples

Example 1

To a 1-liter five-necked separable flask equipped with a stirrer, a thermometer, a reflux condenser and a nitrogen inlet tube were added 2.5 g of a homopolymer of acryloyloxyethyltrimethylammonium chloride, 112.5 g of ammonium sulfate and 335 g of deionized water and dissolved, then 35.1 g (90 mole %) of acrylamide and 14.9 g (10 mole %) of acryloyloxyethyltrimethylbenzylammonium chloride were charged, then heated to 50°C and the ^{air}inside was displaced by nitrogen.

One g of a 1% aqueous solution of 2,2'-azobis(2-amidino-propane)hydrochloride was added thereto as a polymerization

initiator, and the polymerization was conducted with stirring at 50°C for 10 hours to obtain a polymer in the form of fine particles dispersed in the salt aqueous solution.

The viscosity of this product was 500 cp at 25°C, and the viscosity of this polymer at 0.5% in 1 N sodium chloride aqueous solution was 22.0 cp.

Example 2

To the separable flask used in Example 1 were added 3.8 g of a copolymer obtained by polymerizing acrylamide and acryloyloxyethyltrimethylammonium chloride at a molar ratio of 75:25, 42.5 g of aluminum sulfate, 42.5 g of sodium sulfate and 336.2 g of deionized water and dissolved, then 52.7 g (90 mole %) of acrylamide and 22.3 g (10 mole %) of acryloyloxyethyltrimethylbenzylammonium chloride were charged, then heated to 50°C and the ^{air}inside was displaced by nitrogen.

1.5 g of a 1% aqueous solution of 2,2'-azobis(2-amidinopropane) hydrochloride was added thereto, and the polymerization was conducted with stirring at 50°C for 10 hours to obtain a polymer in the form of fine particles dispersed in the salt aqueous solution.

The viscosity of this product was 2400 cp at 25°C, and the viscosity of the polymer at 0.5% in 1 N sodium chloride aqueous solution was 32.0 cp.

Example 3

To a 1-liter five-necked separable flask equipped with a stirrer, a thermometer, a reflux condenser, a nitrogen inlet tube and a dropping funnel were added 1.3 g of a homopolymer of methacryloyloxyethyltrimethylammonium chloride, 90 g of sodium sulfate and 318.7 g of deionized water and dissolved, then heated to 50°C and the ^{air} inside was displaced by nitrogen. Thereafter, that obtained by mixing and dissolving 34.6 g (90 mole %) of acrylamide, 15.4 g (10 mole %) of methacryloyloxyethyltrimethylbenzylammonium chloride, 40 g of deionized water and 0.05 g of 2,2'-azobis(2-amidinopropane) hydrochloride was put into the dropping funnel, and gradually added dropwise to the salt aqueous solution with stirring. By polymerizing at 50°C for 10 hours, a polymer was obtained in the form of fine particles dispersed in the salt aqueous solution.

The viscosity of this product was 1080 cp at 25°C, and the viscosity of the polymer at 0.5% in 1 N sodium chloride aqueous solution was 20.0 cp.

Example 4

To the separable flask used in Example 1 were added 3.8 g of a copolymer obtained by polymerizing acrylamide and methacryloyloxyethyltrimethylammonium chloride at a molar ratio of 50:50, 127.5 g of ammonium sulfate and

293.7 g of deionized water and dissolved, then 30.0 g (70 mole %) of acrylamide, 12.4 g (10 mole %) of dimethylaminoethyl methacrylate sulfate and 32.6 g (20 mole %) of acryloyloxyethyl dimethylbenzyl ammonium chloride were charged thereinto, heated to 40°C, and the ^{air}inside was displaced by nitrogen.

0.38 g of a 10% aqueous solution of ammonium persulfate and 0.38 g of a 10% aqueous solution of sodium hydrogen-sulfite were added thereto, and the polymerization was conducted with stirring at 40°C for 10 hours to obtain a polymer in the form of fine particles dispersed in the salt aqueous solution.

The viscosity of this product was 2820 cp at 25°C, and the viscosity of the polymer at 0.5% in a 1 N sodium sulfate aqueous solution was 17.0 cp.

Example 5

To the separable flask used in Example 1 were added 10 g of a homopolymer of dimethylaminoethyl methacrylate sulfate, 100 g of sodium chloride and 290 g of deionized water and dissolved, then 32.9 g (65 mole %) of acrylamide and 67.1 g (35 mole %) of acryloyloxyethyl dimethylbenzyl chloride were charged thereinto, heated to 50°C, and the inside was displaced by nitrogen.

0.5 g of a 10% aqueous solution of 2,2'-azobis(2-

amidinopropane) hydrochloride and 0.5 g of a 10% aqueous solution of sodium hydrogensulfite were added thereto, and the polymerization was conducted with stirring at 50°C for 10 hours to obtain a polymer in the form of fine particles dispersed in the salt aqueous solution.

The viscosity of this product was 1920 cp at 25°C, and the viscosity of the polymer at 0.5% in a 1 N sodium sulfate aqueous solution was 18.0 cp.

Example 6

To the separable flask used in Example 1 were added 6.3 g of a homopolymer of acryloyloxyethyltrimethylammonium chloride, 131.3 g of ammonium sulfate and 237.4 g of deionized water and dissolved, then 54.4 g (50 mole %) of methacryloyloxyethyltrimethylammonium chloride and 70.6 g (50 mole %) of acryloyloxyethyldimethylbenzylammonium chloride were charged thereinto, heated to 50°C, and the air inside was displaced by nitrogen.

1.3 g of a 10% aqueous solution of 2,2'-azobis(2-amidinopropane) hydrochloride was added thereto, and the polymerization was conducted with stirring at 50°C for 10 hours to obtain a polymer in the form of fine particles dispersed in the salt aqueous solution.

The viscosity of this product was 2120 cp at 25°C, and the viscosity of the polymer at 0.5% in a 1 N sodium

sulfate aqueous solution was 10.3 cp.

Example 7

To the separable flask used in Example 1 were added 5.0 g of methacryloyloxyethyltrimethylammonium chloride, 100 g of magnesium sulfate and 295 g of deionized water and dissolved, then 100 g of methacryloyloxyethyldimethylbenzylammonium chloride was charged thereinto, heated to 50°C, and the ^{air} inside was displaced by nitrogen.

1.0 g of a 10% aqueous solution of 2,2'-azobis(2-amidinopropane) hydrochloride was added thereto, and the polymerization was conducted with stirring at 50°C for 10 hours to obtain a polymer in the form of fine particles dispersed in the salt aqueous solution.

The viscosity of this product was 1080 cp at 25°C, and the viscosity of the polymer at 0.5% in a 1 N sodium sulfate aqueous solution was 14.0 cp.

Example 8

To the separable flask used in Example 3 were added 8.8 g of a copolymer obtained polymerizing acrylamide and acryloyloxyethyltrimethylammonium at a molar ratio of 40:60, 113.8 g of sodium dihydrogenphosphate and 158.6 g of deionized water and dissolved, heated to 50°C, and the inside was displaced by nitrogen. Thereafter, that obtained by mixing and dissolving 175 g of acryloyloxyethyldimethylammonium

chloride, 43.8 g of deionized water and 0.18 g of 2,2'-azobis(2-aminidopropane) hydrochloride was placed in a dropping funnel, and gradually added dropwise to the salt aqueous solution with stirring. The polymerization was conducted at 50°C for 10 hours to obtain a polymer in the form of fine particles dispersed in the salt aqueous solution.

The viscosity of this product was 460 cp at 25°C, and the viscosity of the polymer at 0.5% in a 1 N sodium sulfate aqueous solution was 13.5 cp.

Example 9

To the separable flask used in Example 1 were added 10 g of a homopolymer of methacrylamidopropyltrimethylammonium chloride, 120 g of ammonium sulfate and 270 g of deionized water and dissolved, 100 g of acrylamidopropyldimethylbenzylammonium chloride was charged thereinto, then heated to 50°C, and the ^{air}inside was displaced by nitrogen.

1.0 g of a 10% aqueous solution of 2,2'-azobis(2-amidinopropane) hydrochloride was added thereto, and the polymerization was conducted with stirring at 50°C for 10 hours to obtain a polymer in the form of fine particles dispersed in the salt aqueous solution.

The viscosity of this product was 960 cp at 25°C, and the viscosity of the polymer at 0.5% in a 1 N sodium sulfate

aqueous solution was 15.0 cp.

Example 10

Into the separable flask used in Example 1 were charged 75 g of acrylamide, 106.3 g of ammonium sulfate, 7.5 g of ethylene glycol and 311.2 g of deionized water, heated to 45°C and the ^{air}inside was displaced by nitrogen.

2.3 g of a 1% aqueous solution of 2,2'-azobis(2-amidinopropane) hydrochloride was added thereto as a polymerization initiator, and the polymerization was conducted with stirring at 45°C for 10 hours to obtain a polymer in the form of fine particles dispersed in the salt aqueous solution.

The viscosity of this product was 2060 cp at 25°C, and the viscosity of the polymer at 0.5% in 1N sodium chloride aqueous solution was 30 cp.

Example 11

Into the separable flask used in Example 1 were charged 75 g of acrylamide, 50 g of ammonium sulfate, 25 g of diammonium hydrogenphosphate, 3.8 g of glycerin and 296.2 g of deionized water, heated to 40°C, and the ^{air}inside was displaced by nitrogen.

0.75 g of a 1% aqueous solution of ammonium persulfate and 0.75 g of a 1% aqueous solution of sodium hydrogensulfite were added thereto, and the polymerization was conducted

with stirring at 40°C for 10 hours to obtain a polymer in the form of fine particles dispersed in the aqueous solution. The viscosity of this dispersion was 8400 cp at 25°C, and the viscosity of the polymer at 0.5% in 1 N sodium chloride aqueous solution was 70.2 cp.

When 50 g of diammonium hydrogenphosphate was further added to this dispersion, the viscosity was reduced to 350 cp.

Example 12

Into the separable flask used in Example 1 were charged 43.6 g (90 mole %) of acrylamide, 6.4 g (10 mole %) of sodium acrylate, 112.5 g of ammonium sulfate, 2.5 g of pentaerythritol and 335 g of deionized water, heated to 40°C, and the ^{air}inside was displaced by nitrogen.

1 g of a 1% aqueous solution of ammonium persulfate and 1 g of a 1% aqueous solution of sodium hydrogensulfite were added thereto, and the polymerization was conducted with stirring at 40°C for 10 hours to obtain a polymer in the form of fine particles dispersed in the salt aqueous solution.

The viscosity of this product was 1830 cp at 25°C, and the viscosity of the polymer at 0.5% in 1 N sodium chloride aqueous solution was 25.5 cp.

Example 13

Into the separable flask used in Example 1 were charged 51.5 g (90 mole %) of acrylamide, 23.5 g (10 mole %) of sodium 2-acrylamido-2-methylpropanesulfonate, 106.3 g of ammonium sulfate, 3.8 g of sorbitol, 3.8 g of propylene glycol and 311.1 g of deionized water, heated to 45°C, and the ^{air} inside was displaced by nitrogen.

3.8 g of a 1% aqueous solution of 2,2'-azobis(2-amidinopropane) hydrochloride was added thereto, and the polymerization was added thereto, and the polymerization was conducted with stirring at 45°C for 10 hours to obtain a polymer in the form of fine particles dispersed in the salt aqueous solution.

The viscosity of this product was 910 cp at 25°C, and the viscosity of the polymer at 0.5% in 1 N sodium chloride aqueous solution was 40.7 cp.

Example 14

Into the separable flask used in Example 1 were charged 57.6 g (90 mole %) of acrylamide, 4.2 g (5 mole %) of sodium acrylate, 13.2 g (5 mole %) of sodium 2-acrylamido-2-methylpropanesulfonate, 63.8 g of ammonium sulfate, 42.5 g of sodium chloride, 7.5 g of polyethylene glycol #400 and 311.2 g of deionized water, heated to 45°C, and the ^{air} inside was displaced by nitrogen.

2.3 g of a 1% aqueous solution of ammonium persulfate

and 2.3 g of a 1% aqueous solution of sodium hydrogensulfite were added thereto, and the polymerization was conducted with stirring at 45°C for 10 hours to obtain a polymer in the form of fine particles dispersed in the salt aqueous solution.

The viscosity of this product was 1200 cp at 25°C, and the viscosity of the polymer at 0.5% in 1 N sodium chloride aqueous solution was 35.1 cp.

Example 15

Into the separable flask used in Example 1 were charged 52.7 g (90 mole %) of acrylamide, 22.3 g (10 mole %) of acryloyloxyethyltrimethylbenzylammonium chloride, 51 g of aluminum sulfate, 34 g of sodium sulfate, 3.8 g of glycerin and 336.2 g of deionized water, heated to 45°C, and the air inside was displaced by nitrogen.

1.5 g of a 1% aqueous solution of 2,2'-azobis(2-amidino-propane) hydrochloride was added, and the polymerization was conducted with stirring at 45°C for 10 hours to obtain a polymer in the form of fine particles dispersed in the salt aqueous solution

The viscosity of this product was 2100 cp at 25°C, and the viscosity of the polymer at 0.5% in 1 N sodium chloride aqueous solution was 40.3 cp.

Example 16

Into the separable flask used in Example 1 were charged 35.3 g (65 mole %) of acrylamide, 45.4 g (22 mole %) of acryloyloxyethyltrimethylammonium chloride, 19.3 g (13 mole %) of acryloyloxyethyltrimethylammonium chloride, 68.8 g of ammonium sulfate, 2.5 g of ethylene glycol, 2.5 g of polyethylene glycol #200 and 270 g of deionized water, heated to 45°C, and the ^{air}inside was displaced by nitrogen.

2 g of a 1% aqueous solution of 2,2'-azobis(2-amidinopropane) hydrochloride was added thereto, and the polymerization was conducted with stirring at 45°C for 10 hours to obtain a polymer in the form of fine particles dispersed in the salt aqueous solution. The viscosity of this dispersion was 2500 cp at 25°C, and the viscosity of the polymer at 0.5% in a 3% sodium sulfate aqueous solution was 50.6 cp.

When 56.2 g of diammonium hydrogenphosphate was further added to this dispersion, the viscosity was reduced to 390 cp.

Example 17

Into the separable flask used in Example 1 were charged 56.6 g (90 mole %) of acrylamide, 18.4 g (10 mole %) of methacryloyloxyethyltrimethylammonium chloride, 51 g of ammonium sulfate, 34 g of diammonium hydrogenphosphate, 2.3 g of glycerin, 1.5 g of ethylene glycol and 336.2 g of

deionized water, heated to 50°C, and the ^{air}inside was displaced by nitrogen.

1.5 g of a 1% aqueous solution of 2,2'-azobis(2-amidinopropane) hydrochloride was added thereto, and the polymerization was conducted with stirring at 50°C for 10 hours to obtain a polymer in the form of fine particles dispersed in the (salt) aqueous solution.

The viscosity of this product was 3510 cp at 25°C, and the viscosity of the polymer at 0.5% in 1 N sodium chloride aqueous solution was 15.1 cp.

It is also possible to use a polymer electrolyte soluble in a salt aqueous solution in combination with a polyol. Such examples are given as Examples 18 and 19.

Example 18

To the separable flask used in Example 1 were added 3.8 g of a homopolymer of sodium acrylate (the viscosity of its aqueous solution having a pure content of 0.5% being 10 cp at 25°C), 50 g of ammonium sulfate, 25 g of diammonium hydrogenphosphate, 3.8 g of propylene glycol and 292.4 g of deionized water and dissolved, 75 g of acrylamide was added thereto, heated to 45°C, and the ^{air}inside was displaced by nitrogen.

2.3 g of a 1% aqueous solution of ammonium persulfate and 2.3 g of a 1% aqueous solution of sodium hydrogensulfite

were added thereto, and the polymerization was conducted with stirring at 45°C for 10 hours to obtain a polymer in the form of fine particles dispersed in the salt aqueous solution. The viscosity of this dispersion was 7200 cp at 25°C, and the viscosity of the polymer at 0.5% in 1 N sodium chloride aqueous solution was 35.3 cp.

When 50 g of potassium sulfate was further added to this dispersion, the viscosity was reduced to 450 cp.

Example 19

To the separable flask used in Example 1 were added 2.3 g of a homopolymer of acryloyloxyethyltrimethylammonium chloride (the viscosity of its aqueous solution having a pure content of 0.5% being 20 cp at 25°C), 85 g of ammonium sulfate, 3.8 g of glycerin and 333.9 g of deionized water and dissolved, 34.7 g (75 mole %) of acrylamide, 31.5 g (18 mole %) of acryloyloxyethyldimethylbenzylammonium chloride and 8.8 g (7 mole %) of acryloyloxyethyltrimethylammonium chloride were charged thereinto, heated to 45°C and the ^{air} inside was displaced by nitrogen.

2.3 g of a 1% aqueous solution of 2,2'-azobis(2-amidinopropane) hydrochloride was added thereto, and the polymerization was conducted with stirring at 45°C for 10 hours to obtain a polymer in the form of fine particles dispersed in the salt aqueous solution.

The viscosity of this product was 720 cp at 25°C, and the viscosity of the polymer at 0.5% in a 3% sodium sulfate aqueous solution was 65 cp.

Example 20

To the separable flask used in Example 1 were added 7.5 g of a homopolymer of sodium acrylate (the viscosity of its aqueous solution of a pure content of 0.5% being 10 cp at 25°C), 42.5 g of ammonium sulfate, 42.5 g of diammonium hydrogenphosphate and 331.8 g of deionized water and dissolved, 75 g of acrylamide and, as a chain transfer agent, 0.75 g of isopropyl alcohol were charged, heated to 40°C, and the ^{air}inside was displaced by nitrogen.

0.75 g of a 1% aqueous solution of ammonium persulfate and 0.75 g of a 1% aqueous solution of sodium hydrogen-sulfite were added thereto as polymerization initiators, and the polymerization was conducted with stirring at 40°C for 10 hours to obtain a polymer in the form of fine particles dispersed in the (salt) aqueous solution.

The viscosity of this product was 2300 cp at 25°C, and the viscosity of the polymer at 0.5% in 1 N sodium chloride aqueous solution was 40.2 cp.

Example 21

To the separable flask used in Example 1 were added 7.5 g of a homopolymer of sodium 2-acrylamido-2-methyl-

propanesulfonate (the viscosity at a pure content of 0.5% being 20 cp at 25°C), 100 g of ammonium sulfate and 292.5 g of deionized water and dissolved, then 75 g of acrylamide was charged thereto, heated to 45°C, and the ^{air} inside was displaced by nitrogen.

0.75 g of a 1% aqueous solution of ammonium persulfate and 0.75 g of a 1% aqueous solution of sodium hydrogen-sulfite were added thereto, and the polymerization was conducted with stirring at 45°C for 10 hours to obtain a polymer in the form of fine particles dispersed in the salt aqueous solution. The viscosity of this dispersion was 7500 cp at 25°C, and the viscosity of the polymer at 0.5% in 1 N sodium chloride aqueous solution was 65 cp.

When 25 g of diammonium hydrogenphosphate was further added to this dispersion, the viscosity was reduced to 550 cp.

Example 22

To the separable flask used in Example 1 were added 2.5 g of a homopolymer of sodium acrylate (the viscosity of its aqueous solution of a pure content of 0.5% being 10 cp at 25°C), 2.5 g of a homopolymer of sodium 2-acrylamido-2-methylpropanesulfonate (the viscosity of its aqueous solution of a pure content of 0.5% being 30 cp), 112.5 g of ammonium sulfate and 332.5 g of deionized water and dissolved,

43.6 g (90 mole %) of acrylamide and 6.4 g (10 mole %) of sodium acrylate were charged thereinto, heated to 45°C, and the ^{air}inside was displaced by nitrogen.

1.5 g of a 1% aqueous solution of 2,2'-azobis(2-amidinopropane) hydrochloride, and the polymerization was conducted with stirring at 45°C for 10 hours to obtain a polymer in the form of fine particles dispersed in the salt aqueous solution.

The viscosity of this product was 3800 cp at 25°C, and the viscosity of the polymer at 0.5% in 1 N sodium chloride aqueous solution was 35.5 cp.

Example 23

To the separable flask used in Example 1 were added 7.5 g of a homopolymer of sodium 2-acrylamido-2-methylpropanesulfonate (the viscosity of its aqueous solution of a pure content of 0.5% being 19 cp at 25°C), 106.3 g of ammonium sulfate and 310.5 g of deionized water and dissolved, 51.5 g (90 mole %) of acrylamide, 23.5 g (10 more %) of sodium 2-acrylamido-2-methylpropanesulfonate and, as a chain transfer agent, 0.75 g of benzyl alcohol were charged thereinto, heated to 45°C, and the ^{air}inside was displaced by nitrogen.

2.3 g of a 1% aqueous solution of 2,2'-azobis(2-amidinopropane) hydrochloride was added thereto, and the polymerization

was conducted with stirring at 45°C for 10 hours to obtain a polymer in the form of fine particles dispersed in the salt aqueous solution.

The viscosity of this product was 1500 cp at 25°C, and the viscosity of the polymer at 0.5% in 1 N sodium chloride aqueous solution was 25 cp.

Example 24

To the separable flask used in Example 1 were added 7.5 g of a homopolymer of sodium acrylate (the viscosity of its aqueous solution of a pure content of 0.5% being 10 cp at 25°C), 51 g of ammonium sulfate, 34 g of diammonium hydrogenphosphate and 331.8 g of deionized water and dissolved, then 57.6 g (90 mole %) of acrylamide, 4.2 g (5 mole %) of sodium acrylate, 13.2 g (5 mole %) of sodium 2-acrylamido-2-methylpropanesulfonate and, as a chain transfer agent, 0.75 g of isopropyl alcohol were charged therein^{or}, heated to 40°C, and the ^{air} inside was displaced by nitrogen.

1.5 g of a 1% aqueous solution of ammonium persulfate and 1.5 g of a 1% aqueous solution of sodium hydrogen-sulfite were added thereto, and the polymerization was conducted with stirring at 40°C for 10 hours to obtain a polymer in the form of fine particles dispersed in the salt aqueous solution.

The viscosity of this product was 1030 cp at 25°C, and

the viscosity of the polymer at 0.5% in 1 N sodium chloride aqueous solution was 30 cp.

Example 25

To the separable flask used in Example 1 were added 3.8 g of a homopolymer of acryloyloxyethyltrimethylammonium chloride (the viscosity of its aqueous solution of a pure content of 0.5% being 20 cp at 25°C), 51 g of aluminum sulfate, 34 g of sodium sulfate and 336.2 g of deionized water and dissolved, then 75 g of acrylamide was charged thereinto, heated to 50°C, and the ^{air} inside was displaced by nitrogen.

1.5 g of a 1% aqueous solution of 2,2'-azobis(2-amidino propane) hydrochloride was added thereto, and the polymerization was conducted with stirring at 50°C for 10 hours to obtain a polymer in the form of fine particles dispersed in the salt aqueous solution.

The viscosity of this product was 4100 cp at 25°C, and the viscosity of the polymer at 0.5% in 1 N sodium chloride aqueous solution was 55 cp.

Example 26

To the separable flask used in Example 1 were added 3.8 g of a homopolymer of methacryloyloxyethyltrimethylammonium chloride (the viscosity of its aqueous solution of a pure content of 0.5% being 100 cp at 25°C), 106.3 g of ammonium

sulfate and 314.9 g of deionized water and dissolved, then 56.6 g (90 mole %) of acrylamide and 18.4 g (10 mole %) of methacryloyloxyethyltrimethylammonium chloride were charged thereinto, heated to 45°C, and the ^{air}inside was displaced by nitrogen.

1.5 g of a 1% aqueous solution of ammonium persulfate and 1.5 g of a 1% aqueous solution of sodium hydrogen-sulfite were added thereto, and the polymerization was conducted with stirring at 45°C for 10 hours to obtain a polymer in the form of fine particles dispersed in the salt aqueous solution.

The viscosity of this product was 2550 cp at 25°C, and the viscosity of the polymer at 0.5% in 1 N sodium chloride aqueous solution was 20.3 cp.

Comparative Example 1

To the separable flask used in Example 1 were added 112.5 g of ammonium sulfate and 337.5 g of deionized water and dissolved, then 35.1 g (90 more %) of acrylamide and 14.9 g (10 mole %) of acryloyloxyethyldimethylbenzylammonium chloride were charged thereinto, heated to 50°C, and the ^{air}inside was displaced by nitrogen.

1.0 g of a 1% aqueous solution of 2,2'-azobis(2-amidinopropane) hydrochloride was added thereto, and the polymerization was conducted with stirring at 50°C for 10

hours to obtain a polymer in the form of dispersed particles of a particle diameter of 2 - 3 mm, but when the polymer to be co-present was not present as above, these particles, after one night's standing, stuck to each other to grow into a mass and did not disperse again.

Comparative Example 2

To the separable flask used in Example 1 were added 112.5 g of ammonium sulfate and 337.5 g of deionized water and dissolved 50 g of acrylamide was charged thereinto, heated to 40°C, and the ^{Air}inside was displaced by nitrogen.

1 g of a 1% aqueous solution of ammonium persulfate and 1 g of a 1% aqueous solution of sodium hydrogensulfite were added thereto, and the polymerization was conducted with stirring at 40°C, but 10 minutes later, the viscosity is increased and the whole system became a mass.

Example 27

The products of this invention produced by the examples and a product produced by conventional aqueous solution polymerization were compared for the properties.

Table 1

Product Name	Concentration of the Polymer	Solution Viscosity ¹⁾	Product Viscosity
Example 1	10 (%)	22.0 (cp)	500 (cp)
2	15	32.0	2400
3	10	20.0	1080
Aqueous Solution Polymerized Product ²⁾	10	20.0	Gel form and shows no flowability

- 1) The solution viscosity is the viscosity of the polymer at 0.5% in 1 N sodium chloride aqueous solution.
- 2) The monomer composition of the aqueous solution polymerized product was the same as in Examples 1 and 2.

Thus, those having the same molecular weight were obtained as flowable products having lower viscosity as compared with the aqueous solution polymerized product.

Example 28

The products of this invention produced in the examples and a commercially available powdered product were compared for the time to be completely dissolved in water.

(Dissolution was conducted by a magnetic stirrer to make an aqueous solution of 0.2% of the polymer).

Table 2

Product Name	Concentration of the Polymer	Solution Viscosity ¹⁾	Dissolution Time
Example 1	10 (%)	22.0 (cp)	20 (min)
2	15	32.0	20
3	10	20.0	20
Powdered ²⁾ Product	95	20.0	60

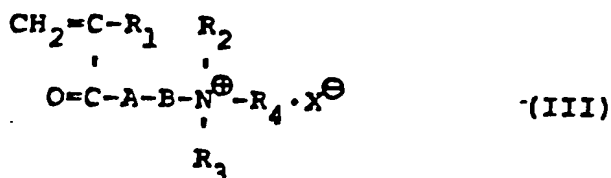
- 1) The solution viscosity is the viscosity of the polymer at 0.5% in 1 N sodium chloride aqueous solution.
- 2) The monomer composition of the powdered product was the same as in Examples 1 and 2.

Thus, it was found that the dissolution time is very rapid as compared with the powdered product.

The features disclosed in the foregoing description and in the following claims may, both separately and in any combination thereof, be material for realising the invention in diverse forms thereof.

CLAIMS

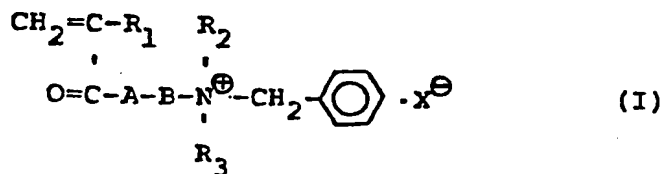
- 5 1. A process for the production of a water-soluble polymer dispersion, which process comprises polymerizing a water-soluble monomer with stirring in an aqueous solution of at least one salt, in the presence of a dispersant.
- 10 2. A process according to Claim 1, wherein the salt and the salt concentration are such that the polymer is not dissolved and the dispersant is dissolved.
- 15 3. A process according to Claim 1 or 2, wherein the dispersant is a polyol.
- 20 4. A process according to Claim 3, wherein the polyol is one or a mixture of two or more of ethylene glycol, propylene glycol, glycerin, pentaerythritol and sorbitol.
- 25 5. A process according to Claim 3, wherein the polyol is polyethylene glycol and/or polypropylene glycol having a molecular weight of up to 600.
- 26 6. A process according to Claim 1 or 2, wherein the dispersant is a polymer electrolyte.
- 30 7. A process according to Claim 6, wherein the dispersant is a polymer of an acrylic acid alkali metal salt and/or a 2-acrylamido-2-methylpropanesulfonic acid alkali metal salt or a copolymer containing 30 mole % or more thereof.
- 35 8. A process according to Claim 6, wherein the dispersant is a polymer of one or more cationic monomers of the formula (III) below or a copolymer containing 20 mole % or more thereof:



wherein R_1 is H or CH_3 ; R_2 and R_3 are each an alkyl group of 1 - 2 carbon atoms; R_4 is H or an alkyl group of 1 - 2 carbon atoms; A is an oxygen atom or NH; B is an alkylene group of 2 - 4 carbon atoms or a hydroxypropylene group; and X^- is an anionic counterion.

9. A process according to any one of the preceding claims, wherein 85 mole % or more of the water-soluble monomer is acrylamide.

10. A process according to any one of Claims 1 to 8, wherein the water-soluble monomer is a mixture of one or more cationic monomers of the formula (I) below and other monomer(s) copolymerizable therewith at a molar ratio in the range of 100:0 to 5:95:

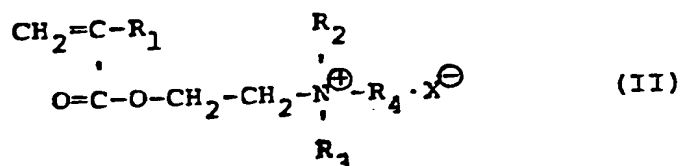


wherein R_1 is H or CH_3 ; R_2 and R_3 are each an alkyl group of 1 - 3 carbon atoms; A is an oxygen atom or NH; B is an alkylene group of 2 - 4 carbon atoms or a hydroxypropylene group; and X^- is an anionic counterion.

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11. A process according to any one of Claims 1 to 8, wherein the water-soluble monomer is a monomer mixture of one or more cationic monomers of the formula (II) below and (meth)-acrylamide, the monomer(s) of the formula (II) being up to 15 mole %:

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- 20 wherein R_1 is H or CH_3 ; R_2 and R_3 are each an alkyl group of 1 - 3 carbon atoms; R_4 is H or an alkyl group or alkanol group of 1 - 3 carbon atoms; and X^- is an anionic counterion.

- 25 12. A process according to any one of Claims 1 to 8, wherein the water-soluble monomer is a monomer mixture of a (meth)acrylic acid alkali metal salt and (meth)acrylamide, the (meth)acrylic acid alkali metal salt being up to 15 mole %.

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13. A process according to any one of Claims 1 to 8, wherein the water-soluble monomer is a monomer mixture of a 2-acrylamido-2-methylpropanesulfonic acid alkali metal salt and (meth)acrylamide, the 2-acrylamido-2-methylpropanesulfonic acid alkali metal salt being up to 15 mole %.

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